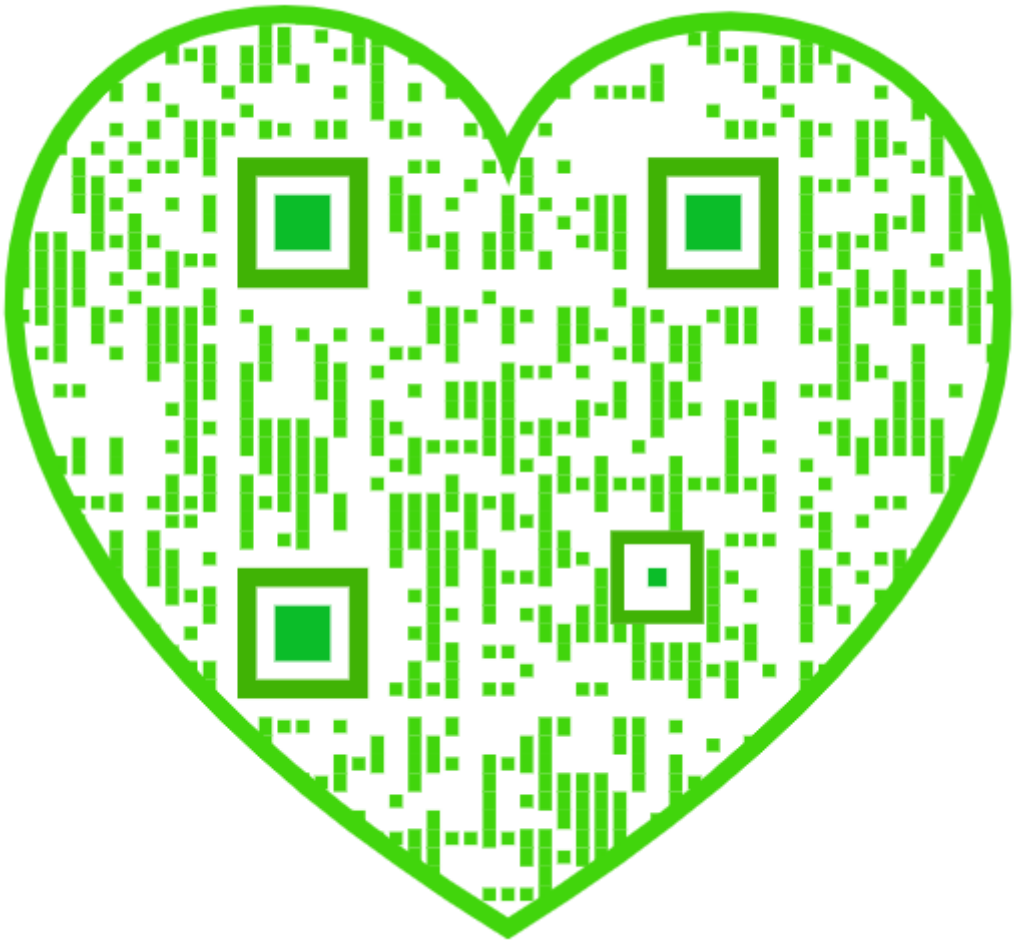

SUGGESTED RULES

FOR

RECOVERING COAL MINES AFTER EXPLOSIONS AND FIRES.

BY

W. E. GARFORTH,

Mem.Inst.C.E., F.G.S.,

Past President of the Mining Association of Great Britain,
Chairman of the Mining Committee of the University of Leeds.

LONDON:
THE COLLIERY GUARDIAN CO. LIMITED
(THE CHICHESTER PRESS)
30 & 31 FURNIVAL STREET, HOLBORN, E.C.

NEW YORK:
D. VAN NOSTRAND CO.,
23 MURRAY AND 27 WARREN STREETS.

1910.

Copyright, 1910, by
WILLIAM EDWARD GARFORTH.

Entered at Stationers' Hall.

THE SCIENTIFIC PRESS
ROBERT DRUMMOND AND COMPANY
BROOKLYN, N. Y.

PREFACE.

EARLY in the present year the writer was invited to contribute a paper to the First International Life-saving Congress held at Frankfort.* Bearing in mind the favourable reception given in 1897 by the members of the Institution of Mining Engineers to his paper on "Suggested Rules for Recovering Coal Mines after Explosions," he decided to write a further paper on the same subject. This decision was partly due to his desire to give additional rules based on further experience, and the knowledge of the advantages to be gained by having men equipped with a portable breathing apparatus, and trained in an experimental gallery made like the damaged roadways of a mine after an explosion, and placed on the surface.

Moreover, having regard to the number of applications which he has received for copies of the 1897 paper, and to the fact that within a few months of its publication no excerpt copies of the *Transactions* could be obtained, the writer ventures to hope these revised rules, which embody the original ones, also those prepared for the Frankfort Congress,* and are the result of thirty-five years' experience of exploration work, may be useful to all interested in coalmining.

The writer has consequently obtained permission from the Council of the Institution of Mining Engineers to copy certain portions of his original contribution, together with the accompanying plans, that the same might be embodied in the present paper. This he now offers in the sincere hope

* This paper was read in June of the present year, and the full text of it is published in the *Bericht* über den I. Internationalen Kongress für Rettungswesen, Frankfurt a.M., 1908.

21434

that the suggestions may prove of service in saving life, relieving suffering, recovering victims, and restoring mines for regular work.

The introduction to the 1897 rules, and the detailed description of the recovery of the Altofts Pit, are given practically as originally written. The writer gives the latter account to show how helpful the rules (at that time unpublished) were proved to be. In the present paper, it is hoped, by giving the number of the rule opposite such description of the work of recovery, the reader will be able to consider its applicability and how it could be adopted under somewhat similar conditions without waiting for another disaster to take place.

In addition to the revised rules, footnotes are given, showing how the work of recovering the Altofts Pit might have been rendered safer if the use of portable breathing apparatus had been known in 1886 as it is at the present day.

Amongst other imperfections contained in this paper the length of the rules may be mentioned, but the writer regrets he cannot abbreviate them without sacrificing clearness to conciseness. Most of the suggestions are intended as **reminders** rather than rules. Time is not of vital importance when reading "Precautions to be taken before an Accident," and with respect to "Rules for Guidance after an Accident," it is advisable there should be no ambiguity when danger is imminent. It is also desired that each section of the rules should be complete in itself, hence a certain amount of overlapping and repetition has been inevitable.

SNYDALE HALL,
NORMANTON,
24*th October* 1908.

CONTENTS.

PART I.

PAGES

INTRODUCTION, showing the Necessity for Formulating Rules ... ... 7—13

SUGGESTED PRECAUTIONS to be taken BEFORE an ACCIDENT ... ... 13—28

I., II., III.—Appointment of Emergency Officials, Ambulance Stores, Food, &c. ... ... 13—15

IV. to V.—Preparation of Mechanical and other Special Appliances, Safety and Electric Lamps, etc. .. .. 15—17

VI. to VII.—Ventilation, Fan Drift, Separation Doors, &c. .. 17—18

VIII.—Sections and Plans of Shafts and Underground Workings for the Use of Explorers. . ... 19—20

IX.—Instructions to Workmen, Need of Special knowledge and Training for Rescue Work, and Suggestions should men be entombed .. .. 20—22

X. to XIII.—Equipment of Rescue Stations and Requirements of the Portable Breathing Apparatus—Danger attending use of Apparatus with Untrained Men ... ... 22—27

NOTE.—See page 29 for Contents Part II. giving Suggested Rules for Guidance AFTER an Accident.

OF THE
UNIVERSITY
OF
CALIFORNIA

INTRODUCTION.

IN an address which, as president of the Midland Institute of Mining, Civil and Mechanical Engineers, the writer had the honour to deliver in August 1893, he drew the attention of members to the necessity of formulating a number of rules to help in recovering a mine after an explosion. The hope was expressed that, with the aid of the members of the societies forming the Federated Institution of Mining Engineers, a sufficient number of individual experiences might be collated to permit of the issue of special and local rules for the use of those (especially the younger members) who might be suddenly called upon to render assistance in an accident in which many lives are jeopardised if not already lost. In July 1891, when giving evidence before the Royal Commission appointed to consider the question of Explosions from Coaldust in Mines, the writer made a similar suggestion, and offered to submit to the Commissioners certain rules which had proved of service in exploration work, but they were considered outside the scope of their inquiry. Indeed, from the time of the Astley Pit explosion in 1874, when sixty-two lives were lost, the writer has felt the need of having, in a concise form, rules and suggestions similar to those now proposed, which, in the form of a handbook, could be quickly referred to and their adaptability grasped while on the way to the scene of some colliery disaster.*

Considering the full and detailed accounts which have been written during the last century, by some of the most

* The time required to read aloud the suggested rules is rather less than forty-five minutes, and the scientific aids about six minutes.

experienced and scientific men of this and other countries, to explain the cause of colliery explosions and suggesting precautions to prevent their occurrence, it seems somewhat strange that the mining world does not to-day possess a code of rules, which would be of practical use in a time of great excitement and confusion such as usually follows a colliery explosion. Those members who have never passed through the sad experience and the terrible anxiety following an explosion, but have taken every possible precaution to avoid one, may say that the writer's propositions are unnecessary, and that there are at the present time sufficient restrictions in carrying out the several Acts of Parliament relating to colliery management. In reply, it may be pointed out that previous to 1851, or before serious legal restrictions were placed on the getting of coal, the loss was one life for 219 persons employed, whilst in 1896 the loss was only one life for 675 persons employed or 190,596 tons of coal raised.*

Unfortunately, explosions are not things of the past; they continue to occur in spite of all the skill and care of colliery officials, often at the pits which are considered "the safest in the district." It is usually the unexpected which happens, and it is therefore prudent to be prepared fully for every emergency, especially having regard to contemplated legislation.

The best time to judge of the utility of formulating rules is not when all connected with a colliery is working satisfactorily, but rather when standing near the mouth of some pit which has recently fired, surrounded by a crowd of anxious relatives waiting in dreadful suspense. At the same time, scores of men, with hearts as brave as ever beat on land or

---

* For the year 1906 the loss was one life for 886 persons employed, or for 249,305 tons of coal raised.

sea, are offering to face any danger in a noxious atmosphere, with a miserable light and no means of escape except by a deep shaft, which, with its attendant appliances, may have been more or less damaged by the force of the explosion. Such men the poet Wordsworth describes:—

> "He holds no parley with unmanly fears:
> Where duty bids he confidently steers,
> Faces a thousand dangers at her call,
> And, trusting in his God, surmounts them all."

With such a fearless body of men the manager, in his anxiety not to incur the risk of further loss of life, naturally hesitates as to the best course to take. Although there can be no exact rules, since each case must depend upon circumstances, still, if the manager thus suddenly called upon had before him, in the form of suggestions and sketches, a knowledge of the means which had proved successful at a neighbouring colliery some years before, or of the mistakes committed at another colliery, as a result of which a second explosion and further loss of life occurred, it would help to show him what to do and what to guard against. It might also tend to reduce the feeling of helplessness more or less present, when man is face to face with a calamity brought about by the forces of nature. Indeed it sometimes happens that the shock caused by the sudden news of an explosion interferes with that clearness of judgment which is essential at such a critical moment.

Statistics show that explosions, previous to 1860, resulted in the loss of 2·98 lives per explosion, and since that date the loss has been at the rate of 6·25 lives per explosion. This increase is partly due to the increased depth of the mines from the surface, which necessitates the adoption of the longwall packgate system of working, and to roadways now being made through the goaf, and often resting on timber. The

roadways are also much longer than formerly, and covered with a greater quantity of coal dust due to increased traffic, which assists in propagating a greater explosive blast; consequently when timber is blown out by an explosive blast, the falls are heavier, and the pit is therefore more difficult to recover.

For many years past the writer has given general assistance at several collieries where explosions and fires have taken place. As the result of such experience he ventures to submit a number of rules or reminders for the consideration of the members. It will be noticed that some of them are such as would naturally occur to the mind in its normal condition as the best way of meeting difficulties. But, unfortunately, the mind is at such times not in its ordinary state, consequently certain instructions which should have been issued at the outset are overlooked, and when given later they do not possess the same value.

In this age of science, strength of muscle is as burnt flax to beaten iron in comparison with strength of mind. The colliery official can spare the former, but must possess the latter; he must also have a clearness of perception, and a grasp of mind which overlooks no difficulties, but provides every available means of overcoming them. Temporary reverses and discouragements should nerve him to increased efforts, and strengthen his resolution to overcome them. No merchant at his books, nor mathematician at a problem, should display a greater regard for minute details than the chief of an exploring party.

It would facilitate the working of such rules if members in coal mining districts, which in the past have been subject to colliery explosions, would give the benefit of their experience to members in other districts hitherto free from such disasters. Difficulties in these latter may arise in the future, consequent

on deeper mines being worked. In any case the formulation of rules might result in raising the standard of discipline. A discussion of them might also be the means of saving time when even a few minutes are of vital importance. For instance, if two or more members met at the scene of an explosion, then the remembrance of the reasons which led to the formation of certain rules at an Institute meeting would assist them in arriving at a decision with greater promptitude than if they had not previously discussed the subject.

The alternative is to continue in the old-fashioned way. This means that mining engineers and colliery officials of the future will have to incur responsibility (sometimes even to close a mine) with imperfect information before them and suffer the same mental strain as that which their predecessors have undergone. In addition to which there are the increased responsibilities consequent on the inquiry usually held by the Home Office, claims for compensation under the Workmen's Compensation Act, and the greater losses resulting from the stoppage of large collieries. This policy, it must be admitted, is not in keeping with the various practical and scientific improvements which in recent years have been carried out at many collieries.

What is desired is a thorough consideration of the question. There may be difficulties, but "obstacles to a true policy only test its validity." The writer trusts that the members of the Federated Institution of Mining Engineers will, by the aid of some of the fundamental rules here suggested, construct a general code in which each mining district will incorporate other rules applicable to flat or inclined coal seams and local conditions, which can be supplemented afterwards by a number of sketches to aid the eye.

If this proposal be carried out on these lines, it is to be expected that, besides reducing the number of explosions by guarding against their occurrence, and recovering the pits more systematically and with less risk to those engaged, there will be a consciousness in the minds of both the older and younger members of having supplied a want which has long been felt, and in having carried out a scientific work by which colliery officials will be saved many of the anxieties and difficulties which have been suffered in the past.

The writer trusts that these rules or reminders will receive the approval of H.M. Inspectors of Mines, who have already contributed valuable papers to and taken part in discussions connected with the Federated Institution of Mining Engineers. As regards explosions, they have had special experience, and mining engineers and colliery managers have cause to feel deeply indebted for valuable advice received from them during times of great anxiety.

The prevention of causes contributory to accidents, as for example the accumulation of firedamp, formation of dust on main roads, use of explosives, &c., cannot be here referred to, as such subjects have been extensively treated in other mining papers. The writer has, therefore, confined his remarks solely to suggesting means whereby the effects of explosions or underground fires may be minimised.

It is hoped that the consideration of these rules or reminders will increase rather than lessen the heroism which has been shown at previous disasters.

Although these suggested Rules have been drawn with due regard to existing Acts of Parliament and Home Office Orders in force in the Coal Mines of this Country, still if they admit of an interpretation contrary to that conveyed by either existing or future legislation, the latter will, of course, take precedence.

SUGGESTED PRECAUTIONS TO BE TAKEN BEFORE AN ACCIDENT.

In the event of a serious disaster, the time, thought and expense given to preparation for it will be amply repaid. Should such a contingency never arise, the simple fact that it is provided for, as far as human foresight can go, may draw the attention of the colliery officials to some weak point hitherto overlooked, which may be the means of minimising the effects of a disaster.

" Fore thought will often save much after thought."

" Prevention is better than cure."

" Forewarned is forearmed."

I. ARRANGEMENTS WITH STAFF.

(*a.*) During the ordinary working of the colliery, the leading officials should be requested to consider what steps should be taken to avoid ordinary accidents, and should also make every possible preparation to deal with a serious accident should one occur.

(*b.*) Appointment of Emergency Officials.—Having regard to the unexpected work and anxiety devolving on the Manager and chiefs of exploration parties in the event of a disaster, it is most essential that the appointment of emergency officials should be made beforehand, and given in writing. By this means every official would have ample time to consider his position and duties, and anything approaching confusion which would otherwise naturally occur would be obviated.

The following appointments are suggested:—

(*c.*) Underground officials to co-operate with the Manager and Under-manager; they should have a sufficient experience of the pit to take charge, in the absence of their superiors, until the arrival of His Majesty's Inspector of Mines for the District, and if required to continue the work of exploration.

(*d.*) Supplementary exploration officials thoroughly acquainted with all the details of the workings, including disused parts of the mine, regularly trained to wear portable breathing apparatus, and qualified to act as leaders of rescue parties.

(*e.*) Officials to take charge of the surface, see that all messages are promptly delivered, that the different rescue parties are present at the stated times, that no man obtains a safety lamp or descends the pit unless his name is on the special list of men approved by the Manager or his deputy, attend to the telephone, act in conjunction with the constabulary, keep the crowd from running unnecessary risks by approaching too near to the pit, and render general assistance.

(*f.*) A chief and chief-assistants of ambulance corps, to make arrangements for attending to the injured, prepare for the reception of the dead, make lists of the names of injured and dead, take full particulars for identification, and answer enquiries from relatives.

(*g.*) Officers to measure the quantity of air passing at the shafts and at the various splits, to record the temperature at the different parts of the mine as the work of exploration proceeds, and to test the condition of the air at the upcast shaft with instruments, mice, small birds or other means.

(*h.*) Supply officers to provide restoratives for the sufferers and food for the explorers; they should also be responsible for the prompt supply of timber, non-inflammable brattice cloth, and all other material required.

II. AMBULANCE STORES.

In addition to the usual stock of ambulance materials * required by law (General Rule 34, Coal Mines Regulation Act, 1887), a good supply of the following should be kept at hand:— Cotton wool, boric gauze or lint, carron oil (oil and limewater), blankets, water bottles with straps, cups for carrying brandy, &c.; hermetically-sealed boxes of specially-prepared chocolate should also be stocked. All these stores should be occasionally examined and renewed when necessary. A supply of oxygen with suitable cylinders and masks for administration, and a number of extincteurs or "fire queens" with re-charges should be kept available for immediate use.

III. FOOD.

Provision should be made for supplying refreshments, such as tea, coffee, cocoa, bread and butter, and sandwiches; for carrying these, cans with hot water jackets, and tin boxes with divisions to prevent the contents from becoming mixed are recommended. Arrangements should be made to have the use of two rooms, one near the pit and the other near the offices, where refreshments can be promptly given out.

IV. WINDING APPLIANCES.

(*a.*) Consider the safest and quickest method of descending into the mine in case the usual winding appliances at both downcast and upcast shafts are rendered useless or temporarily disabled.

(*b.*) It is suggested that cross girders and other necessary appliances should be placed in the pit headgear to carry a suitable pulley. In the event of the headgear being damaged a similar pulley might be carried on girders or timbers placed

* It is assumed that every colliery has an efficient ambulance corps, and that the members of it will be able to render first aid and carry out the doctor's instructions.

across the shaft; the necessary material for this should be kept on hand.*

(*c.*) A winding or capstan engine, with sufficient galvanised rope (coiled on the drum and shielded from the weather when not in use) to reach to the bottom of the shaft, should be arranged in line with this pulley.* In a shallow shaft it would be possible to fix temporary gear and attach a winding rope to a locomotive, with suitable clamp brake across the pit.

(*d.*) If the ordinary hammer and plate signal cannot be heard on the surface from the bottom of the shaft, arrange a special electric signal, with a suitable cable wound on a reel. The noise made by water falling from damaged water rings or broken joints may sometimes render the hammer and plate signal inefficient even in shallow shafts.

(*e.*) In addition to the ordinary shaftman's saddle, it is suggested that as the shafts are now deeper and larger than formerly a special shaft chair with leather breeches and straps should be provided for sending injured men to the surface, and also for the use of the men making the first descent after an accident. The space below the seat of this chair should be arranged to hold ambulance requirements and tools, and if a flat protection plate or hood is placed above the chair, it is possible for the shaftmen to stand on this and guide it. In case of necessity two injured men and three others could be safely carried by such means.†

---

* These appliances should prove useful in case the cages get jammed in the shaft, while the engine may be arranged for other work, *e.g.*, at one pit the writer has a suitable drum fixed to the hauling engine.

† This appliance is somewhat similar to the rocket apparatus. It gives the explorer the use of both hands, and he cannot fall out when strapped in the leather breeches.

V. ELECTRIC LAMPS AND WATER PIPES.

(*a.*) In addition to the safety lamps in ordinary use, also have in readiness a supply of portable electric lamps. To ensure that the latter are kept in working order they should be used daily for the examination of the shaft and underground machinery.

(*b.*) For protection against surface fires which might affect the shaft or underground roads, a properly arranged system of water pipes, connected to a special fire engine, is essential. The hydrants should be so fixed that a sufficient number of water jets can be quickly obtained from the different branches of the main water pipe, which should be maintained at the maximum pressure. The hoses and nozzles should be stocked in separate buildings, so that a fire occurring in the winding engine house or stores would be extinguished by appliances in the air-compressing engine house, or weigh house, or *vice versa.*

(*c.*) Have a suitable range of water pipes from the surface down the shaft into the mine. This pipe line should be so constructed as to be safeguarded against damage from an explosive blast.*

VI. VENTILATION APPLIANCES.

(*a.*) Have the Ventilating Fan placed at such a distance from the shaft head that it cannot be injured by an explosive blast or affected by fire in the event of the conductors or guides of the upcast shaft becoming ignited.† If such an arrangement has not

---

* These pipes will, in the ordinary course of working, be useful for supplying water to underground stables and for watering main roads, and in this way they will be kept in constant use. Where shafts contain both water and compressed air pipes, suitable arrangements (special joints, extra thickness of metal, &c.) should be made to enable the capacity of both to be used for water or compressed air. Instances can be given where a supply of water at a critical time would have been most valuable, but owing to arrangements not having been made or to being defective, no supply could be obtained.

† General Rule 3, Coal Mines Regulation Act, 1887.

been made, a suitable self-contained engine and fan, capable of producing, say, 80,000 cubic feet of air per minute, should be kept either in stock or at the Joint Rescue Station for a group of collieries; this would not only replace the existing fan in the event of a breakdown, but, if required, could be placed at the top of the downcast to reverse the ventilation.*

(*b.*) Where the downcast and upcast shafts are only a short distance apart, an underground passage or fan drift, equal to an area of at least 40 square feet, should be constructed between the fan and the downcast shaft, with two 9 in. stoppings inserted until actually required. In case of a disaster rendering it necessary to reverse the ventilation, this passage would enable the downcast to be turned into an upcast and the ordinary upcast into a downcast with only a short delay.† It is understood that the separation doors are fitted with latches to prevent them from being opened by the pressure of air on either side. These latched doors should be kept in constant use.

(*c.*) The timber covering of the fan drift, whilst made perfectly airtight, should at the same time be so arranged that in case of an explosion it should act as a safety valve and thereby save the fan itself from possible injury. The fan drift should also be so constructed that it can quickly be repaired by timber and brattice cloth.

VII. FIRE DOORS.

(*a.*) As a protection, in case of a surface fire, iron doors should be provided to close the top of the shafts to prevent smoke going down the shaft and into the workings. The downcast pit should be fitted with permanent iron standards to which panels of sheet iron could be attached to enclose the top of the pit and admit of

---

* This has actually been carried out at several collieries under the writer's directions. In many American mines, owing to the climatic conditions, the fan is arranged to produce either positive or negative ventilation as required.

† Had such arrangement been available in certain instances which can be quoted, many lives might have been saved.

the cages being used. If possible, arrangements should be made that when the doors at the top of the shaft are closed, the intake air can be drawn through the supplementary fan drift previously referred to, or through a branch of such drift outside the area of the pit screens, or down a neighbouring pit and through a road in one of the upper seams. Separation doors connecting the different shafts or workings, which are only used occasionally, should be made of iron and fixed in substantial brick or masonry stoppings.

(*b.*) All shafts connected with the mine should be regularly examined, and the mouthings to disused seams properly safeguarded by stoppings of brickwork, or iron doors.

VIII. PLANS.

(*a.*) Prepare, every six months at least, three cloth tracings from the working plan showing all the roads then open, distinguishing intakes and returns in different colours, marking in the names of all main roads and the numbers of the gate roads, giving an approximate idea of their height, their ordinary condition (dry, damp, or wet), the position of overcasts, doors and sheets, the direction and quantity of ventilation, the position of ambulance boxes, stretchers, stores of oxygen cylinders, purifiers, &c. This plan should be studied as often as possible, especially before the first exploring party descends, as a naturally wet road may have prevented the explosive blast from traversing certain districts, and men may be found alive. In the interval the plans, &c., should be placed in a drawer labelled "Emergency Drawer." *

(*b.*) Prepare a vertical section showing the mines worked, with the various mouthings in the shafts, and all connections

* These plans are required for the Government Officials, Consultative Committee of Engineers, and the first exploring party. They should show the underground workings only, having no regard to the surface, so that neighboring colliery officials engaged on the exploration staff would get no information as regards boundaries, coal leased, thickness of barriers, &c.

between the different mines. Duplicate copies of this section should be kept in the emergency drawer.

IX. INSTRUCTIONS TO WORKMEN.

(*a.*) If the mine is an extensive one, the deputies, in addition to their daily duties, should visit other districts of the pit,say,once a month, so that in case of emergency they may have a general knowledge of other parts of the mine as well as their own district. On specially appointed days also, they should wait until the men are ready to leave their work in order to conduct them to the shaft by other than the usual travelling roads to show them that in case of a disaster there are other ways to both the upcast and downcast shafts.*

(*b.*) A similar plan to those mentioned in Rule VIII(*a*)should be fixed either on the pit bank, or some other prominent position to assist the workmen to know the mine. The attention of the men should be directed to this plan, respecting which the officials should always be able to give information, especially to the trained rescue men, to enable them during their regular practices to discuss such situations as might arise consequent on an explosion or fire. (A large plan of the workings on brattice cloth has been found very useful for this purpose.)

(*c.*) At certain junctions endeavour to arrange definite landmarks which can be distinguished by touch, thereby enabling men to know where they are, even in the dark.

(*d.*) Draw the attention of the under-officials and men, as far as possible, to the necessity of cool-headedness; impress on them the fact that, in the event of an explosion, safety does not necessarily consist in rushing headlong to the shaft. Instances can be given where the working places have proved safer, and they should be left only after due consideration. On the other hand,

---

* This precaution will be interfered with if the Eight Hours Bill, as at present drawn, becomes law.

by getting too far away from the shaft without leaving indications of their whereabouts, the men may become so isolated that they cannot be reached; consequently it should be urged that some of the entombed men should get as near to the shafts as possible to give the rescuers an opportunity of reaching them, and learning particulars of the other entombed men.*

(*e.*) When compressed air is in use in the mine, imprisoned men should consider the advisability of getting air from these pipes. There are advantages to be gained by doing so, but these may be more than counterbalanced by the risks involved in the case of underground fires. Small taps should be provided on compressed air mains for use in case of such an emergency.

(*f.*) If telephones have been installed between the pit bottom and the principal junctions the entombed men should try to get into communication, as it is possible that though the road may be wrecked, the telephone wires, if properly protected, may be in working order.

(*g.*) It is most difficult—not to say impossible—to formulate any definite rules to be observed by entombed men without knowing the special circumstances of each case.† A code of suggestions is recommended pointing out the danger of men trying to escape by a road traversed by an explosive blast. Moreover, certain general instructions should be given to the men as to how they should endeavour to get into touch with rescue parties in the event of an accident, and copies of a code of recognised signals for use between entombed men and rescuers should be kept by the men in their working places.‡ The workmen would, in most cases,

* The Hamstead Colliery disaster was an instance of this kind.

† Some men have been saved after an explosion, whilst others with an equal chance have lost their lives. It may prove useful to collect information from the survivors of colliery explosions as to the means which they adopted.

‡ In many explosions the force and consequent destruction has been so great, and the effects so far-reaching, that it has been evident from the first inspection, that all the underground employees with the exception of a few men and boys near the shaft bottom, have been killed; on the other hand, many explosions can be quoted where it

have to pass through a zone of afterdamp between themselves and the shaft; for this purpose it has been suggested that they should provide themselves with a light form of Rescue Apparatus weighing only a few pounds and of a capacity sufficient to enable a man to walk from his working place to a place of safety. This apparatus should be so arranged as to require little adjustment, the man on an alarm having merely to slip it over his shoulders, affix the helmet, break open the seal on the purifier and turn on the valve regulating the supply of oxygen. Equipped with these, on the occurrence of a disaster, the men could either set off at once for the pit bottom, or await for a limited period the arrival of a rescue party and be conducted by them to safety. An investment in a number of such apparatus by workmen may be looked upon as a form of insurance, and although at many collieries the risk of disaster will be considered so remote that no such life-saving appliances will be adopted, still it is thought that certain men will elect to insure themselves when the way is pointed out to them.

X. RESCUE STATIONS.

It is expected that, in the near future, Central Rescue Stations will be established to supply groups of collieries in every mining district. Men from different collieries will thus become acquainted with each other, and in case of a serious accident it is possible that 50 to 100 or more trained volunteers will be quickly in attendance at the scene of the disaster ready to take part in the relief operations. A description of the construction, maintenance, and utilisation of central stations and of the rescue corps attached to them would exceed the limits of this paper, especially as it would be necessary to meet the needs of each

---

has been subsequently discovered that entombed men have lived for hours and even days after the accident. It seems to the writer fitting, therefore, that some suggestions should be made as to how entombed men should act, and that where the possibility of life exists no efforts to recover entombed men should be spared. "Extraordinary occurrences demand extraordinary remedies."

district, viz., thick and thin seams, flat and steep mines, wet and dry roadways, high temperature, &c. Judging by the discussions which have already taken place at meetings of some of the institutes forming the Institution of Mining Engineers, it is expected that further attention will be devoted to this matter, and codes of rules will be drawn up to suit the various local conditions of each mining centre. Suggestions will also be made for the consideration of collieries respecting the best arrangement for central stations to serve groups of collieries. This "grouping" will depend on the geographical position of collieries in each area. It may be pointed out here that experience has repeatedly shewn that the effects of a serious disaster may be minimised, both as regards life and property, if **immediate assistance** can be given. Each colliery must, and naturally will, consider primarily its own safety; consequently it will be necessary to keep a certain number of portable breathing apparatus, together with stores of oxygen and chemicals, on the colliery premises. This provision will prevent the loss of valuable time by obviating the necessity of waiting the arrival of apparatus, &c., from the central station, which may be some miles distant.

(*a.*) To obtain the full advantage of getting **immediate assistance,** it is suggested that the larger collieries should erect a small gallery to train the men; smaller collieries could utilise an existing building to answer the same purpose at a trifling cost. With such an arrangement, and a supply of oxygen, chemicals, &c., each colliery would have a sufficient number of men within call to form the first and second rescue teams to carry on the work until the arrival of the main body of trained men forming the district rescue corps (who will probably arrive from different directions) and of the superintendent from the central station with further supplies of oxygen, chemicals, &c.

(*b.*) It is also expected that the proposed rules will make provision for the duplicating of oxygen cylinders, purifiers, &c., periodical inspection and testing of all apparatus, stores, &c., and

the registering of the work done by all members so that complete efficiency of both staff and appliances can be maintained.

(*c.*) The central station practices should be additional to those undertaken at the colliery; men will meet at the central station and be enabled to form an opinion of each other's capabilities for work, and an advantageous but friendly spirit of rivalry will be maintained, as experience has shown to be the case in ambulance work. The superintendent at the central station will also be able to form a better opinion of each man's capabilities with the view of recommending individual members as leaders of exploration parties, or suitable for specially difficult work, &c.

(*d.*) The central station should also be the head-quarters for the keeping of registers of attendance, medical officer's reports, complaints of any description, &c.

(*e.*) It should be stipulated that every member of the district rescue corps should agree that he is bound to hold himself in readiness to form one of a rescue party whenever called upon. In the event of wishing to cease being a member, he should give at least one month's notice in writing, so that the chief of each colliery corps may replace him and thereby know on whom to rely.

(*f.*) Minor details of the organisation and control of sub-stations such as the posting of names and addresses of efficient rescue men, special lamp checks—enabling the officials to see at a glance which men are available in case of need—should be left for decision to the management of each colliery.

XI. TRAINING OF RESCUE TEAMS.

(*a.*) The writer submits, as an example of the training and composition of rescue parties, a scheme which is in operation at a colliery employing nearly 2,000 men with several shafts working three separate seams of coal, having a total output of 630,000 tons per annum. The teams comprise twenty-four men,

six from each pit and six from the surface; the surface unit consists of the Manager, the enginewright, three shaftmen, and one electrician; the units from each mine consist of the Under-manager, one deputy (day shift), one deputy (afternoon shift), one deputy (night shift), and two under-officials or workmen; each of these teams is under the direction of the resident Mining Engineer. Each Under-manager has a thorough knowledge of the roadways and methods of ventilation of his own mine, and a general knowledge, gained by periodical visits, of the other seams.

(*b.*) The selected men have been examined and passed by a medical man. They are to be sound in limb, with perfect hearing, of non-excitable disposition, duly certified as qualified ambulance men and thoroughly acquainted with the underground workings of their respective pits.

(*c.*) All the men have been instructed in the construction and handling of the portable breathing apparatus and are able to take it in pieces and put it together again.

(*d.*) Experience in the training gallery has shown that one practice per week for three months is sufficient training to enable a man to pass the efficiency test and become practically qualified. Each team consists of at least five men who practise under a qualified leader; in addition to regular practices in the gallery, exploration of disused underground workings or abandoned roads in the mine is valuable training, either walking upright or creeping on hands and knees: all such practices are strictly carried out as if actual exploration after a disaster were being undertaken.

XII. STORES TO BE KEPT AT RESCUE STATIONS.

The following stock of stores and apparatus should be always on hand at the colliery station:—An adequate number of cylinders each containing 100 cubic feet of compressed oxygen at a pressure of 120 atmospheres; a special pump for charging the cylinders of the apparatus from the store

cylinders without the use of water; the requisite quantity of caustic potash and soda for charging the apparatus; an additional quantity of sealed tins for charging a number of sets of light self-rescue apparatus (if the workmen at any of the collieries in the group have provided themselves with them); an apparatus for supplying oxygen to unconscious men; portable telephone sets and reels of cable for use with and without the apparatus; special stretchers made like sledges for bringing out the injured over fallen roadways; a portable chemical apparatus for analysing samples of the mine air similar to those used for analysing flue gases, and capable of detecting the percentage of oxygen, carbon monoxide and carbon dioxide.* A number of portable electric lamps corresponding to the number of rescue apparatus should be kept ready for use, and smoke helmets similar to those used by firemen might also be stocked for dealing with small fires in the pit or stables, &c.

XIII. REQUIREMENTS OF THE APPARATUS.

The Rescue Apparatus, to be of real practical value, should not be too heavy or cumbersome, and should have its weight distributed over the various parts of the body; an automatic arrangement for the supply of oxygen is essential, as it is often absolutely vital that an explorer should have the free use of both hands; two oxygen cylinders with separate valves are necessary, one for use in advancing and the other for retreating; the gauge recording the pressure of oxygen in the cylinders should be so placed that the wearer can read it either direct or by means of a mirror placed within the protecting cover of the gauge, so that in case he should find himself alone he would immediately be able to determine what amount of oxygen he may have left to enable him to reach a place of safety. The apparatus should allow the head full freedom, and the wearer should be able

* This apparatus will also be found useful for analysing samples of the air in the breathing apparatus during practice.

to breathe in a natural way, not with the nose clipped or the mouth gagged.

The mouthpiece should be so constructed that it may be easily slipped on and off, so that whenever fresh air is encountered, advantage may be taken of it and a corresponding quantity of oxygen saved. The eyes should be protected by goggles for use in smoke, but these should be so arranged that they can be easily removed independently of the helmet as they are often unnecessary in afterdamp. Each apparatus should be capable of supplying the wearer with air as required for a period of at least two hours whilst engaged in laborious work, or for four or five hours if the physical work is easy, as when taking readings of a thermometer in a heated and noxious atmosphere; the cylinders containing the oxygen should be sufficiently strong to withstand a working pressure of 120 atmospheres (1,800 lbs. per square inch) if the generator type of apparatus be used. The chemicals used for the absorption of the carbonic acid gas should be of the very best quality, and not deteriorated by previous exposure to air, and a large surface should be exposed in the purifier for active chemical combination.

SPECIAL WARNING.

In publishing these suggested rules the writer wishes to state once again the opinion he has repeatedly expressed for several years past respecting every form of portable breathing apparatus which has been introduced:—That unless the wearer of the apparatus has systematically and regularly practised for three months in a gallery on the surface made like the damaged roadway of a mine, with confined spaces, &c., and been surrounded with an irrespirable, hot, and occasionally humid atmosphere, for at least two consecutive hours, then such an apparatus, instead of being a help to the wearer, may prove to be a DEATH TRAP.*

* *Trans.* Fed. Inst. Min. Eng., vol. xxii. p. 179, September 1901.

On the other hand, the writer believes that with proper training a brave and cautious man, accustomed to underground work, will be able to render valuable service in saving life, affording relief to sufferers, safeguarding explorers, and protecting property. In support of this opinion the reader is asked to consider the difference between a trained and untrained sailor or soldier.

CONTENTS.

PART II.

PAGES

SUGGESTED RULES FOR GUIDANCE AFTER AN ACCIDENT 31

1— 4...Emergency Officials and Restoratives, &c. 31

5— 9...Winding and Ventilation Arrangements, &c. . 32—33

10—31...Rules for Guidance of Exploration Parties, &c. .. 33—38

32—44...Special Rules in the Use of Rescue Apparatus ... 39—41

45—53...Suggestions relating to the Restoration of Ventilation 42—45

54—56...TREATMENT OF SURVIVORS 46

57—65...Scientific Aids ... ... 46—48

66—67...PROVISION FOR THE Conveyance of Corpses ... ... 48—49

68...DISPOSAL of the Carcases of Dead Horess 49

69...DISINFECTANTS and Precautions taken to prevent Blood-Poisoning 49

70...INFORMATION required for Official Enquiry 50

71...RESTORATION OR ALTERATION OF ROADWAYS for the resumption of Work 51

CONCLUSION 51

SUGGESTED RULES FOR GUIDANCE AFTER AN ACCIDENT.

The Colliery Owners and Manager are the persons ultimately responsible for the conduct of the operations for recovery.

It is gratefully remembered by many colliery officials who have assisted to recover a mine after an explosion, that the Government Inspectors of Mines have on all previous occasions been ever ready with advice and assistance.

When exploration work has been decided upon it should be carried out with firmness and consistency.

"Consider not what might have been done, but what is now to be done."

PERSONS AND MATERIAL TO BE SENT FOR.

1. Telephone or telegraph for His Majesty's Inspector of Mines for the district. Send a carriage or a motor car if at night and he is within driving distance.

2. Send for all emergency officials (*see* Rule I. (*b, c, d, e, f, g, h*)) and the members of rescue teams not in the mine; remind them of their various duties, and impress on them the necessity for coolness in view of the arduous work before them.

3. Send for the colliery doctor and neighbouring medical men.

4. Confer with the leader of the rescue party and the chief of the ambulance corps (or their assistants) as to the appointment of members to descend with the first exploration party, the messages to be sent to the rescue station, the preparation of restoratives, the necessary appliances, the reception of sufferers, &c.

SURFACE ARRANGEMENTS.

5. If the winding appliances be disarranged, get ready special means of descending (*see* Rule V). Among other advantages of getting into the mine quickly are to rescue survivors, to afford relief to the injured and to extinguish fires, which, if allowed to burn, may give rise to complications and cause a further disaster. If the return air shows a cap on the lamp there is a serious risk involved in lowering a safety lamp down the shaft.

6. If the fan drift be damaged, arrange for its immediate temporary repair. Boards overlaid with brattice cloth or with strips of the same are quite sufficient in the early stages of exploration work when only a small quantity of fresh air is usually required. If necessary, arrange for the erection of the special fan and engine (Rule VI).

In the case of shallow mines, the advisability of using a steam jet in the upcast shaft or of causing a downward current of air in the downcast shaft by means of a waterfall may be considered; the latter may be effected by causing the water rings in the shaft to overflow, or by turning a hose-pipe from the surface mains down the shaft.

7. As regards running or stopping the fan in case of a shaft or underground fire no general rule can be given, as decision can only be arrived at by a definite knowledge of the special conditions of each case. If the fan be kept running, the smoke will be drawn through the workings and imprisoned men run a greater risk of being suffocated; on the other hand, if the fan be stopped, firedamp may accumulate in the workings, or disused workings may give off unexpected quantities of gas, and cause a further disaster. Having regard to the loss of life at Thornhill (139 lives lost) and Hamstead (25 lives lost) the course to be pursued seems in favour of stopping the fan for a limited period whilst an exploration is attempted, but only

a knowledge and consideration of local conditions can determine the actual procedure.

8. Place a notice board in a conspicuous position on the pit bank with the following cautions:—

"Real courage does not consist of being careless of danger, but of being quick to face and disarm it."

"Courage without caution is dangerous; caution without courage is contemptible."

9. Have the plans from the emergency drawer (*see* Rule VIII.) laid out in the office so that the principal persons engaged in leading exploration parties may have every opportunity to examine them. Arrange for additional copies to be made, one of which may, if advisable, be placed on the wall to be in constant evidence.

ARRANGEMENT OF EXPLORATION PARTIES.

10. It is well to realise from the commencement that the work of exploration may extend over many days and perhaps weeks. The best available men should be equally distributed over three shifts. Remember that fresh men have succeeded where others in an exhausted condition have failed, good work being impossible without a sufficient amount of sleep and food.*

* The writer has seen explorers carry out splended work when properly rested and supplied with food. One instance attended with important results may be mentioned. Three explorers went forward in a heated and noxious atmosphere to fix a sheet to prevent air feeding a fire. The men returned to the base of operations panting, exhausted and having failed. During a short rest the advantages to be gained by turning the air were pointed out, when the men asked for a drink of warm tea which was handed to them by the leader of the party with encouraging words, whereupon the explorers again went forward and succeeded in fixing the sheet, which was attended with very beneficial results. Now if the men had been faint for want of food, or disappointed that no provision had been made for their convenience, the advantages above-mentioned might have been lost. Another case may also be given; several explorers coming out of a hot pit, with clothes wet from hard work and exhausted for want of food, were told to wait until those in authority could receive their report, and give them

11. Before descending the pit, the Manager should appoint someone to occupy his position in case a serious accident should befall him; he should also arrange that the Under-manager be not engaged in any specially risky underground work at the same time as himself.

12. If the winding appliances at the downcast shaft are uninjured, and the current of air has resumed its normal direction, the first exploring party should descend by this shaft. For exploring with fresh air the following precautions should be observed:—

13. The first exploration party should consist of eight specially selected men, including the Manager or Under-manager, failing which one of the emergency officials should take the vacant place (Rule I.); the leader should record in a special book what work they are attempting to carry out. Two of this party should return to the surface when the general state of affairs at the pit bottom has been ascertained, in order that His Majesty's Inspector of Mines, the Owner, Managing Director, or Consulting Engineer of the colliery may be informed on their arrival of the extent of the

---

fresh instructions. Before these could be obtained the men were cold and disappointed. This lack of forethought was forgotten by the men in remembering their duty, and considering that the management were labouring under difficulties unexpectedly thrown upon them, they returned to work with the same keenness to give of their best, which is so essential in exploration work, and which makes the difference between success and failure. The inconvenience and annoyance suffered might, however, have been avoided had proper directions been given to some under-official, or to some of the workmen's wives, to have always ready in some buildings near the pit and offices, a supply of hot coffee, &c. At the same time certain men should have been attached to each exploring party to provide the men with all necessary refreshments. If strangers from other collieries, but belonging to the same rescue station or group, are in the future called upon to assist in recovering a mine, then the foregoing remarks will specially apply. Alcoholic drinks, or any kind of stimulant, except when used as a restorative, have been proved to be unsuitable for exploration work in connection with colliery explosions or fires. Officials and workmen who desire to do the best and most difficult work, and to be in a condition to face any danger, prefer coffee or tea.

disaster. These two messengers would also be able to state whether additional men were immediately required.

The second exploration party should be properly organised and within call, and ready to respond immediately to a call whenever any specially risky or dangerous work is being attempted.

14. All mouthings in the shafts should, during the descent of the first exploring party, be examined to see whether stoppings are blown out, and (if approved on consultation) arrangements should be made to repair them. There may be a disused connection between the upcast and downcast shafts nearer the surface than the plane of the explosion.

15. It may be necessary on the descent of the first party to stop the cage within speaking distance of the entombed men, to give directions to allay excitement, prevent crowding, &c., according to circumstances.

16. Two men must always be left at the pit bottom, whenever exploration parties are at work, to give the necessary signals in case the party return in an exhausted condition, or when an immediate ascent is necessary, &c.

17. Do not, during the first twenty-four hours, spend time in recovering the dead if there be any chance of saving life. The main objects should be to save life, to prevent further loss of life, to extinguish fires which may cause complications, and to recover the dead.

18. A plentiful supply of approved safety and electric lamps should be kept ready for use, both of which should be doubly inspected considering how dependent the explorer is on his lamp for light and safety. On no account must any lamp be relighted down the pit, but arrangements should be made for supplying fresh lamps at the pit bottom when required. In addition, special signalling appliances (hammer and plate signals, &c.), and any other article or appliance which the exigencies of the case may demand or require, should be at hand. A portable

telephone with cable and reel for connecting the exploration party with the surface has been of great service in some cases.*

19. Have as few men in the pit as possible until satisfactory reports have been gained that there is no fear of a second explosion. Use every method to detect if underground fires exist.

20. The first party should endeavour to get to the sufferers in the workings as quickly as possible, but if in going forward they find a number of men near the pit bottom suffering from burns and other injuries, then two or three of their number should give assistance by supplying:—Carron oil for burns, cotton wool and bandages, brandy, water, rugs or blankets, and oxygen with masks for administration. A supply of lemons for the use of men recovering dead bodies is recommended. The main party should also take pocket thermometers to test the temperature of the mine, and about 20 or 30 feet of rope strong enough to lower men in case the cage cannot reach quite to the pit bottom owing to wreckage.

21. An early opportunity should be taken by the explorers to discover whether the telephones on main haulage roads are intact —assuming telephones have been in use. It is possible that survivors may be within reach of the far end of the telephone, and communication may be maintained with them in this way if the disaster be a fire. To obtain this advantage in case of an explosion, telephone wires require to be specially placed to escape the destructive effects of the explosion.

---

* At the recovery (1901) of the New Moss Pit, 520 yards deep, the Manager of the mine in charge of the first exploration party was able to describe the condition of the shaft to the Managing Director (the writer) on the surface by means of a telephone with reel and cable. Also in extinguishing an extensive fire, a telephone was fixed within a few feet from where the main stopping was being built, say two hundred yards from the shaft. The use of the instrument assisted the officials to obtain a prompt supply of bricks, mortar, clay, &c. It was also the means of saving life when all the party except one (who telephoned) became unconscious from the effects of carbon monoxide given off by the fire.

22. In every case written instructions should, as far as possible, be given to the leaders of exploration parties as to the particular districts parties are to explore and the work they have to perform. (Difficulties have arisen at previous accidents which would have been avoided had this rule been carried out.) Should the exploring party not return within a reasonable time, a reference to the book in which the intentions of the exploring party have been recorded would enable a search party to follow them without delay. The general principle of such records helps to maintain strict discipline.

23. Implicit obedience must be given by every member of the party to the leader. On no account should any man be allowed to explore alone. (This rule is needful to prevent relatives and others from causing unnecessary risks to exploration parties of which they are members.)

24. Exploration parties should advance in single file with suitable intervals between them. The leader should be No. 2, so that No. 1 may act as a scout; the second man in charge should bring up the rear, and be qualified to take charge in case an accident befall the leader.

25. Only the first man of each party must test for gas. Remember that as the strength of a chain is only equal to its weakest link, so the safety of a mine is only equal to the most careless man or most unsafe lamp in it. Each person is responsible for his own lamp and must prevent its exposure to gas unless absolutely necessary. If an explosive atmosphere has been detected it should not be re-tested until means have been taken to render it harmless.

26. Do not let the safety lamp be the final guide as to the existence of afterdamp. A percentage of carbon monoxide smaller than the lamp can detect may be fatal to human life. Mice and small birds have proved useful in detecting small percentages of afterdamp.

27. Explorers travelling over recently fallen roadways should be extremely careful, as the slightest touch may sometimes cause further falls of roof, attended with fatal results.

28. If one person is overcome by afterdamp, remember he is not only thrown out of action, but others are required to carry him back to safety, which may necessitate the return of the party. If it be found necessary to fix a sheet, &c., in a doubtful atmosphere, the person making the venture should call out repeatedly to those of the rescue party in the vicinity to indicate his safety, especially if he has to work on his hands and knees.

29. Parties should be careful not to explore too far at once, even when taking air with them: the force of the explosion may have driven the afterdamp into the interstices of the goaf, from which it may gradually exude into the road through which the party has to return.

30. If strangers from neighbouring collieries are assisting, such party should be accompanied by a qualified official of the colliery under recovery. If the principal officials are incapacitated and strangers are called upon to attempt extra work, a trail of paper or some white powder might with advantage be used to identify their route, since the appearance of a road is soon changed by falls and wreckage.

31. When all hope of rescuing further survivors has been given up, roadways should be made quite safe to travel, the ventilation being first partially restored.

USE OF PORTABLE BREATHING APPLIANCES OR RESCUE APPARATUS.

At collieries where only the downcast shaft is used for winding coal, an explosion is generally most severely felt in the neighbourhood of this shaft and on the haulage roads in its vicinity, probably due to the propagation of the explosive blast by coal dust; on the

return airways, however, and in the neighbourhood of the upcast pit, the stone dust on the floor, sides, roof, &c., usually caused by the passage of men and horses, tends to reduce the explosive blast to inertness. As a result of this, or in case of a fire at the downcast pit, or owing to the winding appliances being damaged, it frequently occurs that a descent can best be made by means of the upcast shaft, and as in such a case the air would be irrespirable, portable breathing appliances would be necessary. The limits of usefulness of the apparatus will depend on the amount of training which the rescuers have undergone in a suitable experimental gallery, the physical condition of the men, the perfectness of the apparatus, the state, height and inclination of the roadways, the heat of the surrounding atmosphere, the obstructions to be removed, and the allowance to be made for contingencies, such as falls of roof between the explorers and safety. The following rules, as well as many of the foregoing, must then be observed.

32. Immediately on being advised of a disaster, the official in charge of the rescue station should despatch to the pit affected the specified number of complete sets of apparatus.

33. All apparatus should be tested before being used, for air tightness. It is suggested that the weigh cabin on the pit bank should be made air-tight, so that by filling it with sulphur or other noxious fumes each explorer could enter it and so test his apparatus before descending the shaft. Apparatus with injectors should be tested by water-gauge, or the quantity of air supplied measured with a suitable appliance such as a graduated bag, which can be unrolled as it is filled. Intermittent or lung-governed valves should be tested by suction before coupling up. All joints subject to high pressure should be made and tested before being sent out of store. The name and address of each man, the number of his check, the pressure of oxygen and the condition of his apparatus should, at the commencement of each shift of exploration work, be recorded in a special book.

34. One member of the rescue party should have a telephone so attached that it can be used while the apparatus is being worn. Pneumatic horns should be worn stitched in the clothing of each member of the party to be sounded by a movement of the arm; these horns would serve as alarms in case anyone was cut off from the main body of explorers, as by a fall of roof, or injured himself or required to draw attention to some danger.

RULES TO BE OBSERVED BY EXPLORATION PARTIES EQUIPPED WITH APPARATUS.

35. The first exploration party wearing the apparatus should consist of eight men; subsequent parties may be reduced to not less than five. While the leading man is taking instructions from the chief in charge of the exploration work, the second in command should be inspecting the apparatus of his party, testing all joints with a lighted taper, and seeing that each cylinder is charged to the maximum pressure (120 atmospheres) and in working order. No man should be allowed to descend the pit if his apparatus shows the slightest defect,if any defect is apprehended, or if his apparatus is in any way uncomfortable. None but efficients—that is, men thoroughly trained in wearing the apparatus, and holding a certificate of competency—should be allowed to form members of such rescue parties.

36. The leader or captain of a rescue party must not interfere in the general conduct of the relief operations unless specially appointed. The management must state what is to be attempted. The leader should, however, be consulted as to whether the plan proposed is practicable for the rescue party, and his opinion should be taken as to the best method of carrying it out.

37. The leader of each party should be relieved as much as possible from extra physical work, his duty being to supervise the work in hand, and to take care of the men under his charge. The other men should share all hard work equally, in order that the oxygen and chemicals of no one apparatus may be exhausted

much earlier than the rest. As soon as any member of the party has used about half his supply of oxygen, the whole party must consult, or indicate by special signs, as to the advisability of returning to a place of safety. Should any man's apparatus not be working satisfactorily he must return immediately to a place of safety accompanied by at least one other man. If the party should by this means be reduced to less than four, risk is involved, and the whole party should return.

38. The same precautions as mentioned in Rule 16 (*c*) as to leaving two men at the pit bottom to give signals, &c., must be strictly observed when men are using life-saving apparatus.

39. Each party should carry two or three pocket thermometers for the reasons already stated, also a light sheet iron stretcher provided with sledge runners (these runners have been found useful in passing over falls). Not only will it be found of service for carrying men, but also for transporting restoratives, food, brattice cloth, tools, &c.

40. During preliminary explorations, the party should not be away from safety for more than about one hour; this time may afterwards be extended, especially if the party is in telephonic communication with the base of operations.

41. As soon as possible, stations or bases should be established in the pit, where the ventilation has been restored, from which extended explorations may be made, and at which the apparatus can be re-charged, thus saving the time, oxygen and chemicals which would otherwise be necessary to enable the men to return to the surface. These stations should be in telephonic communication with the pit bank.

42. Parties wearing apparatus will act chiefly as scouts advancing ahead of the ventilation to prove the existence of and to deal with fires. Their principal and foremost duty will be, however, to relieve survivors cut off from the pit by after-damp. When certain of the roadways have been made

passable for travelling without apparatus, the most convenient arrangement would be to divide each exploration party into men with and without the apparatus; the former would lead and inspire confidence in the latter, as they would be able to rescue them promptly should they be overcome by after-damp, whilst, if the air is breathable but the roadway obstructed by heavy falls, the latter would help to make it passable and expedite the work of recovery.

43. Extra electric lamps should be taken by some members of the party for use in case any of the other lamps get damaged.

44. A relay of men with the apparatus all ready for finally connecting should be in attendance near the pit head, to save time in the event of a sudden call or signal from below ground for further assistance. A further number of men, sufficient to make up two more parties, should also be at hand ready to put on the apparatus immediately the first relay is called upon. Each of these parties would thus in their turn act as chief exploration party.

45. It must be impressed on the men that whilst wearing the apparatus they must not be carried away with the spirit of emulation or work to their utmost strength, but must keep well within the bounds of their own capabilities and those of the apparatus. They will learn by experience when and how much food to take before going on duty.*

RESTORATION OF VENTILATION.

46. If the force of the explosion has blown out stoppings, separation doors, or overcasts, do not restore them immediately, as there may be undiscovered fires. Non-inflammable brattice

* Had there been sufficient relays of men equipped with portable breathing apparatus at the Hamstead Colliery disaster more satisfactory results would have been obtained, and probably the life which was lost might have been saved. Seven men with the apparatus were trying to do the work of thirty.

cloth sheets may be temporarily fixed, as they admit of being pulled down quickly to render the ventilation stagnant when required. Any increase of temperature should be immediately reported to chiefs of exploration parties, and should fire-stink be noticed or other danger apprehended, all men should be immediately withdrawn from the pit and a report made to the Manager or Mining Engineer in charge. It will then be decided either (1) to stop off the district entirely with tight sheets or stoppings of non-inflammable brattice, (2) to try to get to the seat of the fire and extinguish it by water or direct means, or (3) to close the pit entirely with airtight scaffolds in all shafts or by plugging the shaft bottom with *debris*.

In case the pits have to be sealed up, the following methods are suggested:—

Baulks of timber, or preferably iron girders, should be placed across the downcast shaft and covered with planks cut to the circle of the pit; if time permit, these should be coated with non-inflammable paint. The timbers should then be covered over with brattice cloth and puddled with a thickness of clay. Finally, water to a depth of 2 ft. should be run over the whole. If the poisonous fumes from the upcast shaft are so bad that men cannot remain in the shaft sufficiently long to fix the bearers, &c., it is suggested that a frame should be constructed similar to the scaffold used for bricking shafts, with four wings; the whole frame should be capable of insertion inside the guides or other obstructions in the shaft. This should be lowered some 15 ft. or so down the shaft where the brickwork is good. Strips of wood 8 or 9 inches wide and of sufficient size to make up the gap between the inside of the pit and the outside of the frame should then be inserted. This scaffold is simply intended to serve as a platform on which the men can work to put in the main stopping, as the men are then shielded from the noxious fumes coming up the shaft. It would be too risky to allow the closing

of the upcast pit to be dependent on a scaffold supported by chains, therefore holes should subsequently be cut out in the brickwork about 4 ft. above the hanging scaffold and bearers placed across the shaft; finally the stopping should be completed, as in the case of the downcast shaft, by planks, brattice cloth and water. The water should be kept up to a fixed level by means of a short pipe fixed in the shaft, water being run in to make up any deficiency due to evaporation.*

47. If very little damage has been done near the pit bottom and signs of fire, force, falls of roof, and afterdamp are not met with to a serious extent along the main roadways, and the reports from the main returns are satisfactory, communication should be made with the surface with a view of getting additional exploration parties sent into each district. This will hasten the work of recovery and prevent complications arising from accumulations of gases in unventilated districts, as firedamp continues to be given off from the coal in a fiery mine whether ventilation is being maintained or not.

48. When the whole of the underground workings have been wrecked by an explosion, it will generally be found to be the safest plan to recover the workings in sections by temporarily shutting off the air from all districts, except the one being explored and those already recovered. Plan No. I has been specially prepared to explain this important point further. The roads of a recovered district should be subsequently travelled to guard against the outbreak of fires, which may result when the air current has been increased.

49. The system of ventilation which has been approved on consultation must not be altered whilst explorers are in the pit. In the early stage of ventilation, owing to the slight difference in pressure between the intake and return airways, the air-current

---

* The above method was actually carried out as described, which successfully sealed up both shafts of a colliery or mine for eight weeks, when the pits were reopened, and the underground workings recovered.

LIBRARY OF THE UNIVERSITY OF CALIFORNIA

may be easily reversed, therefore extra care is necessary in arranging any particular system.

50. Stoppings made of brattice cloth, which should always be of non-inflammable material, can be best made by leaving the cloth sufficiently long to cover it with dirt at the bottom, and to build packs against it along the sides. To clear a road where the current of air is weak, it is sometimes advantageous to course the air over and under hurdle brattice, *i.e.*, sheets fixed tight at the bottom and open for one or two feet from the roof or *vice versa*. Hurdle brattice sheets are also useful for keeping gas away from a goaf fire. Brattice cloth is of little use for carrying ventilation along a road rendered uneven by heavy falls as the air escapes through the broken stones; for this purpose light sheet iron pipes, 12, 18, or 24 inches in diameter, have been found useful; it is usually the safest plan to make the pipe carry the intake air. Where the ventilating current is insufficient, and compressed air is available, the quantity of air may be increased by arranging a jet of high-pressure air in the centre of the pipe on the injector principle, or a small fan driven by hand may be found useful.

51. If the main intake airways are blocked by heavy falls, consider the advisability of going along the return airways. For this work portable breathing appliances would be safer and quicker, but it can also be done by the explorers laying a range of air pipes as they advance, in the method above described; in this case the intake airways should be stopped off.

52. Remember that there is likely to be fire about the point where the force of an explosion ceased, if there is any inflammable substance such as brattice cloth, doors, timber, tubs, or a feeder of gas in the vicinity.

53. As the work of exploration advances, the ventilation officials should take the temperature and measure the quantity of air on each split at stated periods; these readings should be recorded in a book accessible to the chiefs of exploring parties.

TREATMENT OF SURVIVORS.

54. Wrap up men who have been in afterdamp and prevent them, as far as possible, from exerting themselves. At the same time keep them awake, even to the extent of walking them about supported by two men, with arms over shoulders. The desire to sleep may be so strong that the patient may in his afflicted state cry to be left alone.

55. The lives of men who have been unconscious for only a short time may be saved by the continued use of artificial respiration and the application of oxygen.

56. If the number of victims and sufferers is likely to be large, arrange one of the colliery buildings as a temporary mortuary or hospital; if the former, it should be kept cool.

SCIENTIFIC AIDS.

Scientific aids are given as a warning to explorers to show that the strongest men have often succumbed to the poisonous effects of gases met with in mines.*

57. The presence of carbon monoxide in afterdamp cause, it has been estimated, 70 per cent. of the deaths from colliery explosions. It induces oxygen starvation by strongly combining with hæmoglobin, a complex substance which gives colour to the red blood corpuscles. The function of hæmoglobin is to combine loosely with and carry oxygen from the lungs to the various tissues of the body, and as it will readily yield up its burden of loosely combined oxygen to other bodies having a stronger affinity for oxygen, it is altered by this combination with carbon monoxide and forms carbonic oxide hæmoglobin. Any propor-

* Much valuable information by physiologists and other scientists has recently been published in connection with colliery rescue work which the reader is recommended to study, especially "The Investigation of Mine Air," by the late Dr. Le Neve Foster and Dr. Haldane, published by Messrs. Griffin.

tion above 0.2 per cent. of carbon monoxide in the air is decidedly prejudicial and may be dangerous.

58. Deaths from carbon monoxide poisoning may be recognised by the colour of the blood which is bright scarlet, and not blue as in carbon dioxide poisoning. The bodies of the victims lie lifelike with the lips and tongue pink. A little blood from such a body, if diluted about one hundred fold with water, is pink, differing from diluted normal blood, which is light brown. This test for carbon monoxide in the blood depending on its change of colour, has been proposed by Dr. J. S. Haldane. It should be made in daylight in narrow glass tubes, the diluted blood being compared with similarly diluted normal blood.

59. The symptoms of carbon monoxide poisoning, which are painless, are somewhat in the following order:—Tendency to dizziness, palpitation, shortness of breath, drowsiness, giving way of the legs, loss of consciousness.

60. When a man's blood has absorbed much carbon monoxide, he may on reaching fresh air again become worse and lose consciousness. He may die if the exposure has been long, even after the blood has been freed from the poisonous gas. Possibly this result is due to the chilling effect of the fresh air when the vitality has been lowered by the poisonous gas.

61. The percentage of carbon monoxide necessary to cause death cannot be detected by the ordinary oil safety lamp or directly by the senses. It can be detected by the standard hydrogen flame proposed by Dr. F. Clowes. The best test consists of shaking the air with diluted normal blood and noting the change of colour from light brown to pink when carbon monoxide is present, as suggested by Dr. Haldane.

62. Persons have been kept alive, when fresh air has at once replaced the afterdamp. Air, however, must be breathed for an appreciable time before the carbon monoxide in the blood is replaced by it.

63. Carbon dioxide is not as dangerous as carbon monoxide, and is not directly poisonous. If more than 5 per cent. be present it produces palpitation of the heart, and more than 10 per cent. induces a narcotic effect. As a poison it is slow in its effect. Death caused by this gas is not merely due to the decrease of oxygen in the air, since carbon-dioxide lowers the vital activity even if inhaled in small quantities below 5 per cent., proportions above 5 per cent. produce a rapid effect when breathed.

64. Professor W. Galloway has stated that one volume of fire-damp to fourteen volumes of air is slightly explosive, and one volume to fifteen volumes of air is inflammable.

65. Any gas or vapour which can be kindled or burnt in air may give rise to danger.

HANDLING OF DEAD BODIES.

66. The bodies of the victims should be carried in sheets or soft brattice cloth and sent out to the surface on stretchers. If the bodies are much decomposed, insert brattice cloth under them and then lift them into previously prepared shells of large size, leaving the cloth in the coffins; the finished coffin should be made extra large to allow for this shell, so that no unnecessary handling need take place. The men handling corpses should be provided with disinfectants and leather gloves, with gauntlets, dipped in corrosive sublimate to protect them from blood poisoning. Afterwards thoroughly disinfect the place where each body has lain. Arrangements should be made for numbering each corpse on discovery (attaching a tub mottie is suggested), the same number being marked on a plan to show where each body was found. If the bodies are much decomposed, particular notice should be taken of the clothing for identification purposes, especially of the boots, leather straps, &c., which are not so liable to decomposition as the bodies. [Many painful scenes have taken place among supposed relatives by neglecting this precaution.]

67. It is desirable that the female relatives of the dead should be dissuaded from attempting to see the bodies, especially if they have been in the mine some days.

HANDLING DEAD HORSES.

68. All dead horses should be sent out of the pit as soon as possible if the state of the roads permits of it, as the smell from them soon becomes very offensive, and interferes with the work of recovery. Disinfectants should be freely used. Broad straps should be passed underneath the horse, and attached to a chain and pulley blocks suspended from a tripod or crossbar; the body should then be raised sufficiently high to allow a low-sided tub or tram to be placed underneath; it can then be lowered and sent out of the pit in the usual way without further handling. The stables should be thoroughly disinfected as soon as the bodies have been removed. If the stables are situate some distance in-bye and the falls of roof leading to them prevent the dead horses being sent out of pit, then disinfect as provided for in Rule 69. Where there has been much decomposition of bodies, either of men or horses, the use of portable breathing appliances will prove useful.

DISINFECTANTS.

69. Chloride of lime (bleaching powder) is a most useful disinfectant. The stoving of clothes and free use of disinfectants are necessary.

At Courrières, where the work of recovering bodies lasted five months, the following precautions were taken:—

All men handling corpses wore indiarubber gloves and masks, and before descending bathed their faces, necks and hands in a solution of quassia chips (*Picræna excelsa*) 1 lb. in a bucket of water; between shifts all clothes worn by explorers were stoved under pressure; corpses were sprinkled with a solution of cresol by means of syringes, from as great a distance as possible, and afterwards thoroughly disinfected with about 1 gallon of the same solution (3.2 oz. per gallon). For disinfecting horses and

the places where the carcases had lain, a mixture consisting of 80 parts powdered coal, 10 parts sulphate of iron, and 10 parts chloride of lime was applied. The gloves were soaked for five minutes after each shift in a 1 per cent. solution of permanganate of potash, and afterwards in a 2 per cent. solution of bisulphide of soda, until the red colour produced by the first operation had disappeared. Formal and corrosive sublimate were also used to disinfect boots and woollen clothing.

POINTS TO BE NOTED FOR OFFICIAL ENQUIRY.

70. (*a.*) Nothing connected with the roadways of the mine must be disturbed or removed during the work of exploration unless absolutely necessary for the safety of the explorers, the rescue of survivors, or the recovery of the victims. It is to be observed that the fullest evidence is required by His Majesty's Inspector of Mines for the district to assist in the official enquiry held to discover the cause of the accident. Until all hope of saving further life has been abandoned, time should not be wasted in making notes, but as soon afterwards as possible one member of each exploration party should be deputed for this purpose. Each corpse should be examined for signs of burning and evidence of the explosive blast, or suffocation in case of afterdamp or fumes from a fire. The position of the body, if natural or otherwise, should be noted, also any discoloration of the features, &c.

(*b.*) The following points in connection with the workings should be specially noted:—State of timbering, doors, safety lamps, machinery, coaldust, soot, coke, falls of roof, condition of roads, coal or stone dust in the vicinity, &c.

(*c.*) Evidences of the passage of flame or the burning of men, horses, brattice cloth, timber, &c., must be carefully looked for. Samples of coked coaldust should be minutely searched for, and an analysis of samples of dust taken from various places should be made.

(*d.*) Some objects may show the direction of the blast, but not its force, and *vice versa*. Timber when only partly blown out

is a good guide as to the direction and force of an explosion. The position and condition of each man's safety lamp is useful evidence, particularly when taken in connection with his working place: in some cases the lamp may be near him, but where the man has been subject to the full force of the explosion it may be blown away, or it may be in position still filled with oil, but extinguished by afterdamp, or it may be burnt out and the oil exhausted. The lamp may be found some distance from the body, showing that the man had travelled that distance in the dark before being overcome with afterdamp. The position of the man's clothes, which are taken off while he is working, sometimes affords useful evidence.

RESTORING ROADWAYS FOR WORK.

71. To facilitate the recovery of the pit for work and to avoid sending large quantities of dirt to the surface, prepare a longitudinal section of roads where large falls of roof have occurred, with a view of seeing if the height of some of them will admit of the rail level being raised throughout, so that part of such *debris* will raise the road where no falls have occurred. In this way a good road may be made, and the trouble and expense of sending *debris* to the surface obviated. In timbering roads which have fallen to a great height, some of the dirt may with advantage be packed on the top of the timber; the props supporting such timber should be notched and laced to prevent any of them from being knocked out by derailed tubs. If certain principal roads will be very costly to repair, consider the advisability of substituting others for the conveyance of coal and ventilation requirements.

CONCLUSION.

In conclusion, the writer recommends that each leader of an exploring party should impress on his men the necessity for vigilance and prompt attention to orders, as trifling mistakes may lead to fatal results; that conduct and language should be without reproach, having regard to surrounding dangers; and that whilst courage, experience and rules are essential, it is on God's help that each one must rely for safety and successful work.

DESCRIPTION RELATING TO THE RECOVERY OF THE ALTOFTS PIT.

The following account of the method of recovering this pit is given in extenso, and practically as originally written in 1897. The numbers in the margin refer to some of the rules which were found beneficial. It is therefore hoped the reader will be enabled to judge for himself of their appropriateness and utility without waiting for another explosion to take place.

The explosion in the Silkstone Pit, connected with Messrs. Pope and Pearson's collieries, situate in the West Riding of Yorkshire, occurred on October 2, 1886. The depth of the seam is 1,260 ft. from the surface. The thickness of the seam varies from 3 ft. 6 in. to 3 ft. 10 in., and the inclination is practically level. The output of coal at the time of the explosion was about 1,000 tons per day of eight hours. Only single shifts of men were worked. The colliery had been working for twenty-three years without any serious accident, such as an explosion or fire. Mueseler safety lamps were in use at the time of the explosion but for twenty-two years previously open lights had been used. The pit-bottom and the roadways leading thereto were lighted by artificial gas sent from the surface by means of a steam-jet. The system of ventilation was by furnace, the quantity of air passing was 147,000 cubic feet per minute, or equal to 320 cubic feet per minute per man employed, after making the usual allowances for horses, lights, &c.

No accident had occurred either from the furnace, candles, or the gas-jets, during the period before-mentioned. The area of the goaf was approximately 850 to 900 acres. The mean sectional area of the main haulage roads was about 54 square feet, and of the gate roads and crossgate roads, 44 and 50 square feet respectively. The system of haulage was principally by endless chain. From Plan I, it will be perceived that, after leaving the shaft-pillar, the coal had been worked out entirely on the longwall-packgate system, getting all the coal at one operation. At the time of the explosion, the coal face was respectively distant from the shaft in the direction of No. 1 chain-haulage road, 5,280 ft., the west chain-haulage road, where the explosion occurred, 3,750 ft., the dip-side haulage road 2,400 ft., and the east-side haulage road, 2,490 ft. The explosion occurred on a Saturday, about 3 p.m., when only twenty-eight men and boys were in the pit; these were engaged in repairing certain machinery, widening the west chain-haulage road, and cleaning up coaldust on the haulage roads. Of this number, twenty-two were killed or died within a few days from the effects of the injuries received. The usual number of men and boys employed in the day shift was about 400, but they had left the pit about 1.30 p.m.

The indications on the surface that something unusual had occurred were a very loud report and large volumes of smoke issuing from the upcast pit, which continued for some time. The flat-sheets at the mouth of the downcast shaft and the timber at the top of the upcast shaft were displaced. On arriving at the pit, the downcast current of air was found to be flowing in the right direction. The engineman discovered, on trying to work the winding-engine, that the cage near the bottom of the shaft was in some way

Rule 12.

Rules IV. (c) and 5. jammed or fastened. It was thereupon decided to use the capstan-engine placed within the foundations of the main winding-engine and ordinarily used for examining the upcast shaft. The rope connected with it was fortunately coiled on the drum and uninjured. It was passed over a small-diameter pulley on the headgear of the downcast shaft, which had been fixed many years before the accident. If the headgear had been damaged, baulks would have been placed across the pit and men would have got on the cage at the railway siding level about 18 feet below. A cradle was afterwards attached to the rope and the enginewright and shaft-man descended the downcast shaft, using hammer-and-plate signal, owing to the usual signalling apparatus having been rendered useless by the explosive blast. During the descent it was discovered that a brick stopping at the Stanley Main seam, 240 ft. from the surface, and a stopping at the Warren House seam, 456 ft. deep, were both blown out. The Stanley Main stopping was important, as 300 men were regularly employed in that seam. The Warren House seam was not worked. Nothing else of importance was found to be damaged until reaching a depth of 1,230 ft., when one of the cages was found to be jammed, due to the explosive blast having displaced the wooden conductors. The shaft-men descended until they were able to speak to the survivors congregated at the pit shaft who were in an excited state.

Rule IV. (c). Rule IV. (b). Rules IV. (e) and 5. Rules IV. (d) and 18. Rule 14. Rule 20. Rules IX. (d) and 15.

Rule 13. Rule 12. Rules 11 and 19.

After the shaft-men returned to the surface, the main winding rope attached to the jammed cage was clamped to timbers across the pit-top and detached from the main winding drum to enable the engine to be used for lowering the other cage, which was on the surface at the time of the explosion and undamaged. Mr. Fisher (the certificated manager), Mr. Buxton (the undermanager), five of the leading officials,

and the writer, then descended within a short distance of the pit-bottom.* By means of a mouthing from the side of the shaft and ladders some of the injured men were reached and found to be badly hurt. Two of these men died within a few days, three others who were burnt recovered, the remaining three were uninjured but severely shaken. After sending out the injured men, arrangements were made to extinguish the fire, which was found to be burning near the stables, due, it was supposed, to the explosive blast having ignited some hay, which in turn had ignited the timber covering leading into the stables. Before the fire was extinguished the timber was burnt through, and a large fall of roof took place. Fortunately, the water-pipes, which were used in connection with the stable, were soon repaired, and within twelve hours after the explosion the stable fire was extinguished. It was most fortunate that the explorers were able to get down the pit within a comparatively short time after the accident, as otherwise serious complications would have ensued.†

Rule 22. Rule 20. Rules 4 and 5. Rules 17 and 20. Rule 5. Rule V. (c). Rules 5 & 17.

Whilst some of the men were engaged at the fire, an examination was made of the pit-bottom. It was then discovered that both main stone overcasts had been destroyed, thereby allowing the downcast air to escape direct to the upcast shaft, which was situated within a distance of 72 ft. The men who had been engaged near the engine-house, the two furnacemen, and one of the lampmen, were

Rule 46.

* From the commencement of the explorations until the pit was recovered, the time each official or workman descended or ascended the shaft was carefully recorded, so that it was possible to see at a glance the names of all the men who were underground. (Rules I (*e*) & XIII (*f*)).

† If a similar accident occurred, at the present day and the downcast was impassable by wreckage, the winding appliances disabled, the upcast filled with irrespirable gases but the winding appliances uninjured, then, in the opinion of the writer, there would be no difficulty in descending the upcast by using the portable breathing apparatus.

found dead and severely burnt. The engine-house was badly damaged, and the two furnaces completely wrecked. Seventeen horses in the shaft stables and thirty-five horses in
Rule 6. the east-side stables were found dead. Owing to the water-rings being filled with wreckage, water was running down
Rule VIII. the upcast shaft. On exploring the main roads it was found that heavy falls had taken place within a short distance from the shaft, except on the east side, which was a wet road and where no damage was done. The undercast at No. 6 return airway and the various separation doors and overcasts were
Rules 13 and 20. blown out. The foregoing is a general description of what was discovered, and the work which was carried out underground during the first twelve hours.

Rule VIII. On the surface, the working and other plans showing the system of ventilation, position of the roads, &c., were got ready to assist H.M. Inspector of Mines and the consulting
Rule 9. engineers on their arrival. Cloth tracings were also prepared to assist the explorers. Tea and coffee (hot and cold) without
Rules III. and 10. sugar (to quench thirst), also bread and butter, were supplied to each rescue party by special men.

Rules II., 4, 7 and 20. The ambulance corps, which had been in existence several years previous to the explosion, rendered most valuable assistance. Many times, during the first few hours following the accident, members stated that the relief which they had been able to give to the sufferers amply repaid them for the time and trouble given to the doctor's lectures, practising bandaging, &c.

Rule 1. Mr. Wardell, H.M. Inspector of Mines, arrived during the night, having driven about sixteen miles, owing to there being no train available after he received information of the explosion From his arrival he was in constant attendance

for some weeks, and afterwards he regularly attended consultations until the official enquiry on December 13th, 14th and 15th. The proprietors and all connected with the colliery were deeply indebted to him for valuable advice and assistance. Mr. Jacob Higson, Consulting Engineer to the colliery, and Mr. Marshall Nicholson, Mining Engineer, of Middleton Collieries, near Leeds, were also in close attendance for a considerable time, and rendered valuable services. Their kindness and sympathy are still gratefully remembered. Rule 13.

Instructions were given that nothing connected with the working of the mine should be disturbed unless required for the recovery of the injured or dead. Rule 70.

Before proper organisation could be established, some of the explorers proceeded, over some large falls, up to No. 1 chain-haulage road, with the view of trying to get to some of the missing men. A fall of roof forced the afterdamp upon them; fortunately all escaped without injury except one of the deputies, who was only recovered by the bravery of six men, who carried him in an unconscious state from where he had fallen, to the shaft. Even on getting to the surface, he would have succumbed had it not been for the skill and patience of members of the ambulance corps. This was the only instance of the kind throughout the whole of the explorations, and it proves the necessity for strict discipline from the very commencement of the work of recovery. Rules 19 and 23. Rule 13. Rule 28. Rules II. and 4. Rule 23.

On October 6th the smell caused by the fifty-two dead horses was so offensive that the atmosphere near the pit bottom was unbearable. It was therefore arranged to send the carcases to the surface. Leather gloves with long gauntlets were provided to guard against blood poisoning, and the men were given double pay for this special Rule 68.

work. The men commenced work at 6 o'clock, but for want of experience only succeeded in sending out four horses by 9 o'clock, some of which were accidentally torn limb from limb, thereby increasing the foul smell. It was then arranged to get from the surface some broad leather straps connected with the cart-horse gears and pass them underneath the dead horses as they lay in the stable. When the straps had been placed in position, the dead horse was lifted by means of a tripod stand, differential pulley-blocks and chain sufficiently high to allow an ordinary pit tram for carrying timber to be placed underneath. By these means, thirty-eight horses were
Rule 69. sent out in one day. The roadways were afterwards thoroughly disinfected with carbolic powder, &c.

On October 4 the afterdamp was so strong within a short distance of the shaft that little or no headway could be made. It was thereupon decided to temporarily
Rule 51. restore the main overcast by means of brattice cloth, which was so arranged that in case the fire-stink (which had been noticed in the dip side return airway) became more pronounced the brattice cloth could, in case of emergency, be
Rule 46. immediately pulled down or altered so that the air could pass direct from the downcast into the upcast shaft, thereby leaving the air on the various roadways stagnant. This principle was afterwards carried out at the various connections, viz., No. 6, No. 10, &c., roadways.

It was also decided to erect a temporary fan, as the
Rule 6. upcast shaft was rapidly cooling owing to water running down the shaft. It had been felt for some days previously that, without incurring very serious risk, the furnaces which had been in use for the previous twenty-two years, could never be relighted owing to the large area of goaf, which

was partly filled with explosive gas. No other system of ventilation would have been adequate. Fortunately, the Union Engineering Company had in stock a Schiele fan, 9½ ft. in diameter, sufficient to produce a current of 85,000 cubic feet per minute with a water-gauge of 2½ in. This fan arrived at the pit on Saturday, October 9, and was at once placed on a wooden foundation consisting of baulks of timber, 14 in. square. The fan was driven by a secondhand engine. The drift connecting the fan with the upcast shaft was made of 1 in. timbers covered on the outside, and where necessary on the inside, with brattice cloth and narrow strips of boarding. By working night and day, the engine and fan were running on the following Tuesday night. This arrangement provided sufficient air to recover the pit. Previous to the fan being started, it had been decided to put in tight sheets—in some instances two sheets—in the various intake and return roadways; also to put into No. 6 return airway an opening 18 in. by 12 in., to serve the purpose of an outlet valve for any gas under pressure due to the natural exudation from the coal face or from concussions of air and gas by falls of roof. By means of this valve and an ordinary lamp test, the condition of the atmosphere of the unventilated roads was always obtainable, which information was most valuable to the leaders of the exploring parties.

Rule VI. and 6.

Rule 6.

Rule 46.

Rule 25.

It was realised within a few hours after the explosion that the roadways, some 20 miles in length with hundreds of acres of goaf, would soon become one vast gasometer. The writer suggested that the principle to be adopted for recovering the mine should be to drain or exhaust the natural gas from the goaf gradually in the same way that artificial gas is nightly exhausted from the large gasometers in the various towns. As town gasometers are drained by the

shops, street lamps, and public places, &c., so in the same
Rule 48. way it was argued that the various roadways of the pit might be drained and recovered without accident, provided the pit was divided into panels or districts and each one dealt with separately. All the districts were, therefore, sealed off by
Rule 46. placing double tight sheets and dirt stoppings at every available opening. It was thought that, if any fires existed, this method of preventing the admission of fresh air would be the means of extinguishing them, and later discoveries proved this action to have been correct. The remains of two fires were subsequently found near the end of No. 1 chain-haulage road. Attention is directed to Plan No. I., which shows in different colours, letters and dates when each particular district was recovered.

Rule 46. In consequence of a smell of fire being noticed coming from the dip side return airway, it was considered, for several reasons, that this district could not be dealt with by sealing off in the same way as described in No. 1 chain-haulage road and the other districts C, D, E, F, &c. shown on Plan I. In district A, natural ventilation was taking place, and the smell of fire was
Rule 53. each day becoming more pronounced. The system of recording the ventilation, which had been adopted from October 5th following the explosion, showed that a larger quantity of air than was desired was passing down the dip-side haulage road. Every effort had been made to carry out the work of dressing up the falls with as little air as possible, for it was
Rules I. (g) and 5. feared that there might be other fires. The registration of the various currents was placed in the hands of two assistants, and a report was made to the management every hour of the day and night.

Rule 46. On Friday, October 15th, about 5.20 p.m., the smell of fire becoming stronger, it was decided to discover the cause, and

all the men engaged in cleaning up falls of roof on the roads were withdrawn from the pit. A consultation was held on the surface, and it was decided to make an examination of the dip-side haulage road. At 8 p.m., the writer and Messrs. Fisher and Buxton, accompanied by two deputies, examined the dip-side engine plane road for a distance of 2,100 ft., to a point where a large fall of roof was met with which completely blocked up the roadway. A further attempt was made by means of the east-side haulage road, and the writer, by creeping on his hands and knees, at the same time calling out "all right" to those in the rear got sufficiently near to obtain a distinct smell of fire. On returning to the surface at 10.20 p.m., the fan was stopped until the following morning.

Rules 28 and 52.

Rule 7.

This inspection showed that the fire was being supported by natural ventilation—owing to this district lying to the deep of the shafts—and that the gas from the coal face was gradually accumulating in the roads leading to the fire. It was known that a large area in other parts of the pit was partly filled with explosive gas, and that the shaft-pillar was full of breaks, owing to such pillar not having been left sufficiently large when the seam was originally opened out.

The question of immediately closing the pit and the danger of reopening it at the expiration of several months, taking into account the 850 acres of goaf and broken condition of shaft-pillar, was compared with the risk of attempting to put out the fire without delay. Important matters of detail, local conditions, and the experience that the management, officials, and certain workmen had previously gained in extinguishing other small fires entered largely into the discussion. Eventually it was decided to attempt to extinguish the fire, as it was impossible to judge how soon the gas, which was being given off from the dip-

Rule 46.

Rule 46.

side unventilated coal face, would reach the fire. The fan was
Rule 7. restarted at thirty-five revolutions per minute at 10.30 a.m. on Saturday, October 16th. The same party, assisted by ten
Rule II. additional officials and men, succeeded after twelve hours of hard work, and by using a number of fire extincteurs, in getting within 210 ft. of the point where the fire was supposed
Rule 46. to exist. A non-inflammable sheet of brattice-cloth was placed in No. 4 bord to stop any air-current. The fan was
Rule 7. stopped on the party getting to the surface about 11.30 p.m. At 12.30 a.m. on Monday, October 18th, explorations were resumed, and it was found on getting to No. 4 bord that the atmosphere in the roadway was in better condition than on the previous Saturday night. This improvement enabled a connection to be formed between the dip-side and the east-side haulage roads. The fire was discovered at 3 a.m., near No. 31 gate road, a distance of 2,700 ft. from the shaft. The contents of a number of fire extincteurs were put on the fire. A tight sheet was placed within 1 ft. from the roof, so that
Rule 50. any gas issuing from No. 23 gate road was kept from the fire. Owing to the dip-side haulage road not having been injured, water-tubs could be conveyed to the seat of the fire,
Rule 5. and as the burning material was scraped or turned over it was at once quenched with water. This operation was carried out by four men working together for a period of ten minutes, during which time the smallest possible quantity of fresh air was admitted. At the end of this short time, the men were so exhausted that four others had to take their place. In all
Rule 10. sixteen men were engaged, and these worked in relays of four for periods of ten minutes, or less time if they complained. At the expiration of four to five hours they were replaced by sixteen fresh men. In this way a large quantity of dirt and burnt timber was turned over and well drenched

with water. The work was carried on continuously from Monday at 3 a.m., when the fire was discovered, until 8 a.m. on Tuesday, when it was completely extinguished.* Rule 5.

As soon as the fire had been extinguished, officials were stationed to examine the adjoining roads, &c., at regular intervals. The remaining portion of district A was recovered on the same day, October 19th. Rule 48

During the work of putting out the fire, it had been realised that, had an accident occurred, serious inconvenience would have been caused by the principal officials being in the mine at the same time. It was, therefore, decided that during the remainder of the explorations only the writer and manager, or the writer and under-manager, should be engaged on the same shift. Rule 11.

The writer would like to mention that he proved on this as on previous occasions that a pair of ordinary thick trousers when charged with dust proved a better means of testing an almost stagnant atmosphere than the anemometer, as one slight rap of the hand on the trousers raised a cloud of dust which the least current carried away, allowing at the same time an estimate to be formed of the velocity. Rule 49.

On the morning of October 22nd, Mr. Fisher and the writer, accompanied by two officials, explored district B (Plan I). In travelling Roper's drift, two bodies were discovered. These men were known to have been engaged at

---

* If a party of eight men wearing the portable breathing apparatus had travelled the dip-side road and No. 4's bord where no falls were met with, these explorers could have extinguished the fire within an hour. Had this been done the work of recovery would have been quicker and the fear of a second explosion—which it was predicted would take place,—would have been avoided. If the attempt to put out this fire had been delayed a further twenty-four hours a second explosion would have taken place, as the gas from the dip-side coalface had been accumulating for fourteen days, and was within 40 yards of the seat of the fire when the latter was extinguished.

1.30 p.m. on the day of the explosion, in filling dirt and conveying the same to stow up the roadway between the main intake and return airways, called Roper's drift. The force of the explosion had been sufficient to hurl the men, together with a 14 in. wall and 6 ft. of *debris*, a distance of 111 ft. As the atmosphere in the main west
Rule 25. return airway was found to consist principally of afterdamp, it was not until the following day that Mr. Buxton and four men were able to travel from Roper's drift to the separation doors near the upcast shaft. The bodies of the two men were taken along this road, having been in the pit for three weeks.
Rule 66. Decomposition had taken place, and the bodies were therefore thoroughly disinfected and lifted on to sheets of brattice cloth. Each body was then lifted by means of the cloth—which was left with it—into a specially prepared wooden box, with suitable handles for ropes, and sent to the surface. It was then placed in a polished oak coffin, left sufficiently large
Rule 69. to receive the box. By this method unnecessary handling of the body was avoided, and the risk of blood-poisoning reduced to a minimum.

Rule 71. It was next proved by examination that all the roadways leading to the coal face in district C were in a satisfactory condition, and therefore the work of getting through the falls on the west chain-haulage was commenced. The condition of this roadway is shown in the longitudinal section,
Rule 70. Plate III. The various parts of this roadway were sketched before it was restored. The work of getting a road through the large fall proved difficult at first, owing to the
Rule 50. small quantity of air which could be got to the men. This was due to leakage in the brattice. Although every means was taken to make it tight by stitching and placing props very close together, it was found that the loose stones under

foot allowed the air to escape. It was, therefore, replaced by 2 ft. air-pipes, which on this road and afterwards over other large falls proved of the greatest service. The work in connection with this fall occupied nearly a month—that is, from October 25th until November 17th. The work was carried on continuously night and day from 12 a.m. on Monday morning to 11 p.m. on Saturday night. It was eventually got through, and district D was recovered on November 17th. Some of the fallen roadway measured 18 ft. high. After getting through the fall, tight sheets were placed in No. 10 intake road to prevent fresh air getting into districts coloured brown H and green N on the plan, to carry out the principle of recovering the pit in panels as previously mentioned.

Rules 10 and 31.

Rule 48.

Rule 46.

A few feet beyond Roper's drift, the writer, who was leading an exploration party, discovered the bodies of several men (Nos. 10, 11, 12, 13, 14, 15 and 16). The position of these bodies will be better understood by referring to Plate IV.* Evidence was given at the enquiry to show that they were the bodies of the men who were ordered to blow off about 4½ ft. of roadway on the west chain-haulage road, owing to there being considerable friction on the chain and tubs. This was the first time in the history of this colliery that a shot had ever been fired on a main haulage road. The evidence showed that No. 1 and No. 2 shots had been fired at one time, as some of the men were found in a refuge-place immediately opposite; and No. 3 shot, which there is little doubt caused the explosion, was fired some time afterwards. It

Rules 66 and 69.

Rule 70.

* The writer thinks that it may be of interest to mention that when he saw the plaster-casts in the museum at Pompeii of the victims who were buried in the ashes from Mount Vesuvius (A.D.79), he was struck with the similarity of the attitude or position of the limbs with several of the victims of this explosion. Both appeared to be shielding themselves from an approaching danger.

was from this shot that some of the men were shielding themselves. The roadway for a distance both on the inbye and outbye sides of No. 3 shot was found to be almost undisturbed,
Rule 70. but great force was in evidence in Roper's Drift (*see* Plan No. IV.), shewing the position of the two victims blown from the stopping.

On exploring the main overcast connected with the north-
Rule 46. west district, it was found to have been completely wrecked. This district E (Plan I), was recovered on November
Rule 48. 18th, and the air was allowed to travel on the west chain-haulage road through various gateroads and crossgate roads and back along the main west return airway. The body of deputy Deakin, which was found a few feet down the
Rule 70. north-west crossgate road, was neither burnt nor mutilated, but the mice had eaten part of his body, including the fingers.

Mice were found alive in several parts of the pit, and some of the dead bodies showed that they had been partially eaten by them. Shock appeared to have killed the horses,
Rule 70. as they had no sign of being mutilated. An instance of this took place on the dip-side haulage road. At the time of the explosion, two men were engaged putting in a brick stopping, near which a horse was standing attached to a tub containing mortar. After feeling the rush of air and dust the men made their way to the shaft in the dark, but in doing so had to get over the body of the horse, which was lying in a dying condition in the roadway.

Rule 48. District F belonging to No. 1 chain-haulage road was recovered on November 19th. The tight sheets which had been fixed for more than a month after the explosion, were removed, but owing to the smell of fire which the writer and
Rule 46. other explorers imagined they perceived, only the least quantity of air was allowed to pass during the exploration.

The sheet and relief-valve in No. 6 return airway being retained, it consequently took a considerable time to force out the afterdamp in this road. The difficulty was further increased by the heavy falls in No. 1 haulage road similar to those in the west chain haulage road. The sides and roof of the roadway had the same appearance as a chimney flue, all being covered with soot. Bodies of the two young men who were engaged at the time of the explosion in cleaning up coaldust from the roads, were found on this road badly mutilated, showing force and burning. Rule 70.

After proceeding for some distance, hurdle brattice, that is to say, brattice cloth placed 2 ft. from the roof and hanging down to the floor, was placed every 9 ft. apart. By this means the current was forced closed to the roof. For the reason previously mentioned—that is, before the gas could be forced through the limited area of the relief valve—considerable time was absorbed, especially in overcoming the heavy falls of roof at the intersection of this road with No. 9 crossgate road. It was not until November 26 that district G between No. 1 chain-haulage road and No. 6 return airway could be recovered. Rule 50. Rule 48.

On that date the sheet in No. 6 return airway, together with the safety valve, were removed. During the greater part of the explorations this safety valve was watched day and night, and was the principal guide as to what was taking place in a goaf of several hundred acres. The temperature in the various roads was registered hourly. On the following day district H, between No. 6 return airway and No. 10 intake, was also recovered. On the same day two sheet stoppings on the east side return airway were removed, and the air allowed to circulate round No. 1 to the main east side return airway. Rule 53. Rule 48. Rule 47.

The recovery of districts marked I, J, K, and L, was

Rule 48. accomplished on November 29, 30, and December 1. During the recovery of these districts evidence of fire was found on the road leading from No. 1 chain-haulage road and near crossgate No. 34. Owing to the heavy falls of roof which had taken place at the various points in No. 1 chain-haulage road, especially the heavy fall referred to at No. 9 crossgate road, it was seen that the precautions which had been taken to Rule 46. seal off all the districts to the south-east of the west chain-haulage road were most necessary. It would have been Rule 7. impossible, without running the risk of a second explosion, to have successfully dealt with the fire near No. 32's crossgate owing to the falls in No. 1 road, and the distance (one mile) water would have had to be conveyed.

Districts M and N lying between Nos. 9 and 38 crossgate Rule 48. roads, and between the west chain-haulage road and No. 9 crossgate road, were recovered without any difficulty on December 2nd and 3rd. The body of deputy Lomax was found Rule 70 at the junction of No. 6 return airway with No. 32 crossgate (*d*). road. He appeared as if he had lain down to sleep, his lamp was standing upright with the oil consumed.

No evidence of the explosive blast or of a destructive Rule 70. force was found after leaving the chain-haulage roads, and no other evidence of fire was found in the remaining parts of the pit. It was most noticeable (Plan I. showing falls of roof) that where the haulage roads, *i.e.*, coal dust roads, ceased, the damage ceased and no falls were found or repairs required on the crossgate roads, the gate roads leading to the face, or in the various working-places. There was practically no coal dust after leaving the chain-haulage roads, as the ripping dirt covered over any small coal Rule 70. left in the process of working at the coal face. The tramping of the horses on the dirt or warrant floor also tended to cover

over any pieces of coal which had fallen from the tubs in the gate roads. All the coal faces appeared as if the men had left work an hour before, with the exception of the white appearance of the face due to efflorescence.*

As regards the method of ventilation the following amongst other points may be briefly mentioned.

The volume of air passing down the downcast shaft direct to the upcast shaft, owing to both overcasts being destroyed, varied for some days following the explosion from 40,000 to 60,000 cubic feet per minute. This current was induced by the heat of the brickwork in the upcast shaft. Previous to the explosion, the furnaces produced a current of 147,000 cubic feet of air per minute with 4½ inches water gauge. As the upcast shaft rapidly cooled the ventilating current on the underground roadways reversed several times, Rule 6. whereupon the men were ordered to the surface and the underground explorations were discontinued.

After the fire was extinguished in the dip-side district, marked A on the plan, 5,000 cubic feet of air was sufficient to keep the workings and roadways free from gas. As other parts of the pit were recovered and the water gauge increased, the ventilation in this district gained in proportion until 15,510 cubic feet was registered.

---

* The writer would like to remark that the Altofts Colliery Explosion may not only be cited as being the first at which a coroner's jury returned a verdict of deaths from an explosion of coal dust only, but this disaster indicated at the same time that stone dust was a natural remedy for extinguishing the explosive blast of coal dust. From the evidence of the cooling effects of stone roads on explosive blasts which the writer acquired during three months exploration work and from several years previous knowledge that no accidents had occurred from blown out shots of gunpowder on stone dust roads he suggested the use of stone dust roads as a more effective remedy against the danger of explosions from coal dust than using sprays of water on roadways

When the fan was started 11,000 cubic feet passed on the West Chain road which was gradually increased to recover districts D & E, of which this road formed the main intake. At the commencement of the recovery, and whilst making a passage through the heavy falls, the return air was
Rule 50. carried through a two-feet sheet-iron air pipe, terminating at No. 6 overcast.

As already mentioned the air was allowed to pass direct from the downcast to the upcast shaft in the early stages of the exploration work. But as more air was required on the several roads, the opening in the overcast sheets was gradually reduced and no air was allowed to escape. Until all danger from fires had passed, such sheets were arranged that they
Rule 46. could be instantly removed, and by allowing the air to escape direct to the upcast shaft a stagnant atmosphere was produced on the roads.

It may also be mentioned that owing to the small difference of pressure between the intake and return air-currents the same were almost balanced, consequently the
Rule 49. least alteration in some of the sheets immediately affected in a remarkable manner other currents of air. The system of ventilation is shown on plan I.*

The exploration of all parts of the pit was completed on December 3, 1886.

No accident occurred to any of the officials or workmen during the work of recovery, which occupied three months.

To complete the account of the work of exploration it

---

* In the original paper published in the *Transactions* of the Institution of Mining Engineers, 1897–1898, Volume XIV, page 526, there are five ventilation charts and four sets of tables given to show how the ventilation was registered each hour. The reader is referred to the same if further information is required.

may interest some readers to known the verdict of the Coroner's Jury and the Report of the Inspector of Mines.

The verdict was:—

"That the whole of the workmen killed, except the two deputies (Deakin and Lomax), met their deaths from an explosion of coaldust which originated in the west chain road, which explosion was caused by the firing of an unskilfully drilled shot by one of the workmen engaged in widening the road; and that the two deputies (Deakin and Lomax) were suffocated by the stoppage of ventilation consequent on the explosion."

It may be here mentioned that this was the first time in the history of British mining that a coroner's jury returned a verdict of death from coaldust without the presence of firedamp.

The Official Report (1887) of Mr. Wardell, Chief Inspector of Mines for Yorkshire, on the Altofts explosion stated:—

"I cannot speak too highly of the way in which one and all conducted the slow, tedious operations which ultimately resulted in the fires being extinguished, the bodies recovered, and the pit restored to its working condition. . . . The official staff at the colliery and the bands of workmen all worked like true heroes."

Coals were sent to bank on January 6 for the first time after the explosion, and for the week ending January 13 1,122 tons were raised; in February 3,000 tons, and the weekly output by the end of March was 4,150 tons, which was gradually increased to 1,000 tons per day a few weeks afterwards.

END.